



SUMMARY BY THE CLOUD AND AEROSOL RESEARCH GROUP, UNIVERSITY OF
WASHINGTON, TO OFFICE OF NAVAL RESEARCH ON GRANT NO. N00014-92-J-1587
FROM 15 APRIL 1992 THROUGH 31 DECEMBER 1992

Activity during the 1992 calendar year has centered on our participation in the ASTEX field study and the preliminary analysis of the data collected both in this study and offshore of the State of Washington as a part of a supplement to our ASTEX grant. In both cases, our primary objective was to obtain microphysical data in ship tracks and to associate the ship tracks with measured aerosol emissions from specific ships.

In the course of the ASTEX field study, three research flights were flown specifically to address our research objective. On the first flight, while no actual in-cloud anomaly could be associated with the observed ship emissions, a considerable amount of data was obtained to characterize the emissions from specific ships. On the second research flight, a ship track identified by satellite dissipated before we could reach it and essentially no data was obtained. The third flight constituted our most complete sampling scenario during ASTEX, although it too fell well short of a definitive case study.

The third flight was a multi-aircraft mission including ourselves, the C-130 and the Electra. During the course of a long flight leg for intercomparison, with ourselves above a stratocumulus deck, the C-130 in it and the Electra below it, we detected a narrow region of anomalously high cloud top albedo with our radiometers at roughly the expected position of a remotely sensed ship track. The C-130 reported in-cloud microphysical anomalies at about the same time. We subsequently re-encountered the albedo anomaly and obtained some in-cloud measurements which suggested a lower cloud drop effective radius than that seen elsewhere. However, while the anomaly could have plausibly been associated with an observed ship (based on position and wind velocity), we could not in fact trace it back to the ship. Both we and the Electra obtained measurements in the plume and wake of the observed ship.

DTIC
ELECTE
MAR 03 1993
F

~~STRONG STATEMENT~~

Approved for public release;
Distribution Unlimited

93-02400



706

In addition to the dedicated flights, a considerable amount of data on albedo and microphysical anomalies were obtained during the other ASTEX flights. However, no clear-cut associations of anomalies with ship plumes were ever obtained.

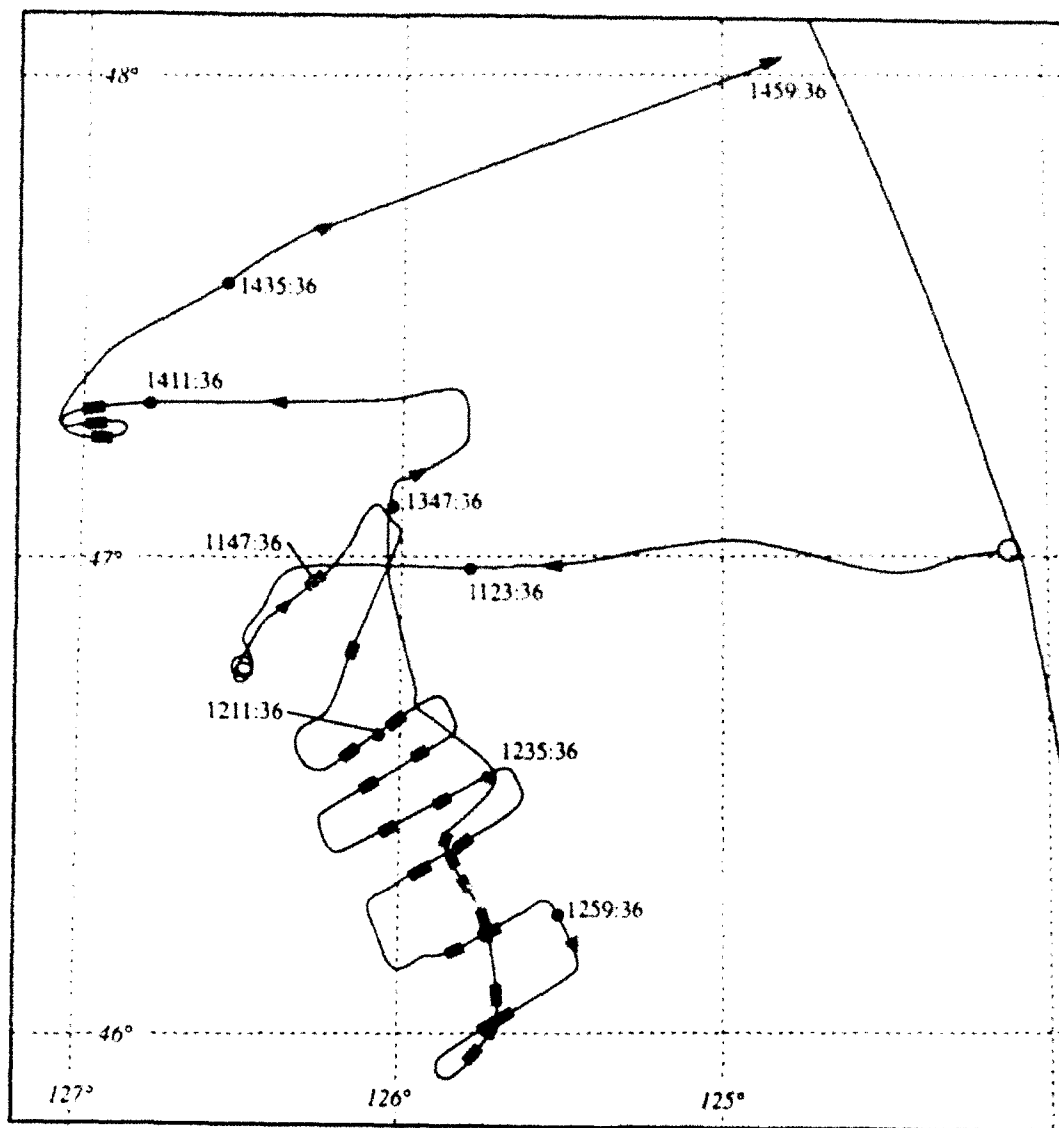
During the course of our supplemental flying off of the Washington Coast, the complete case study that had eluded us during ASTEX was obtained. On August 26, 1992 two ships traveling parallel to the Washington Coast produced ship tracks which were clearly visible in the AVHRR channel 3 imagery. We obtained data in the ship tracks within two hours of the satellite detection. A variety of physical and chemical parameters were measured, both in the tracks and in the surrounding unperturbed clouds, including liquid water content, the cloud drop size distribution and effective radius, cloud water composition, ship stack gases and the CN concentration. The tracks were unambiguously associated with two directly observed ships. Figure 1 shows the flight track of the C-131A with penetrations of the ship tracks indicated by the thick line segments. Figure 2 shows a time series of several key continuously measured variables obtained during a pass through both tracks. In each case, the ship plumes injected a large number of CN into the cloud, dramatically increasing cloud drop number concentrations without proportionately changing the liquid water content of the cloud. Hence, the cloud drop effective radius was significantly reduced and the cloud albedo raised. Cloud water collected in the track showed that only nitrate was enhanced relative to the ambient clouds. This suggests that the ship stack emissions, rather than the ship wake, were responsible for the particles which enhanced the cloud albedo. A synopsis of these results has been presented by R. J. Ferek at the ASTEX ship tracks meeting in Washington D.C. this last December and a journal submission is currently in preparation ("In Situ Measurements of Ship-Induced Cloud Tracks Off the Washington Coast," by R. J. Ferek, P. Durkee, D. A. Hegg and P. V. Hobbs). Another presentation, including large-scale measurements of cloud drop effective radius (which is highly relevant to an assessment of the susceptibility of typical clouds to modification by ship plumes), has been made by M. D. King at the International

WCRP Symposium on Clouds and Ocean in Climate, Nagoya, Japan (Invited). Already in press are two articles dealing with other aspects of the ship track issue, one by P. V. Hobbs, "Aerosol-Cloud Interactions" in Aerosol-Cloud-Climate Interactions, Ed P. V. Hobbs, Academic Press (in press) and one by M. D. King for a forthcoming issue of Earth Observer on the MODIS Airborne Simulator with example imagery from ASTEX.

To date, neither post-docs nor graduate students have been much involved with this ONR-sponsored research effort. However, several graduate students have recently joined our group and we hope to interest them in this project. Finally, we note that P. V. Hobbs has been elected a Fellow of the American Geophysical Union, in part due to his work on cloud-aerosol interactions.

| | |
|--------------------|-------------------------------------|
| Accession For | |
| NTIS | CRA&I |
| DTIC | TAB |
| Unannounced | <input checked="" type="checkbox"/> |
| Justification | |
| By _____ | |
| Distribution / | |
| Availability Codes | |
| Dist | Avail and/or Special |
| A-1 | |

D 1



GPS Track of Flight 1574 - 08/26/92 11:00 - 15:00

Figure 1

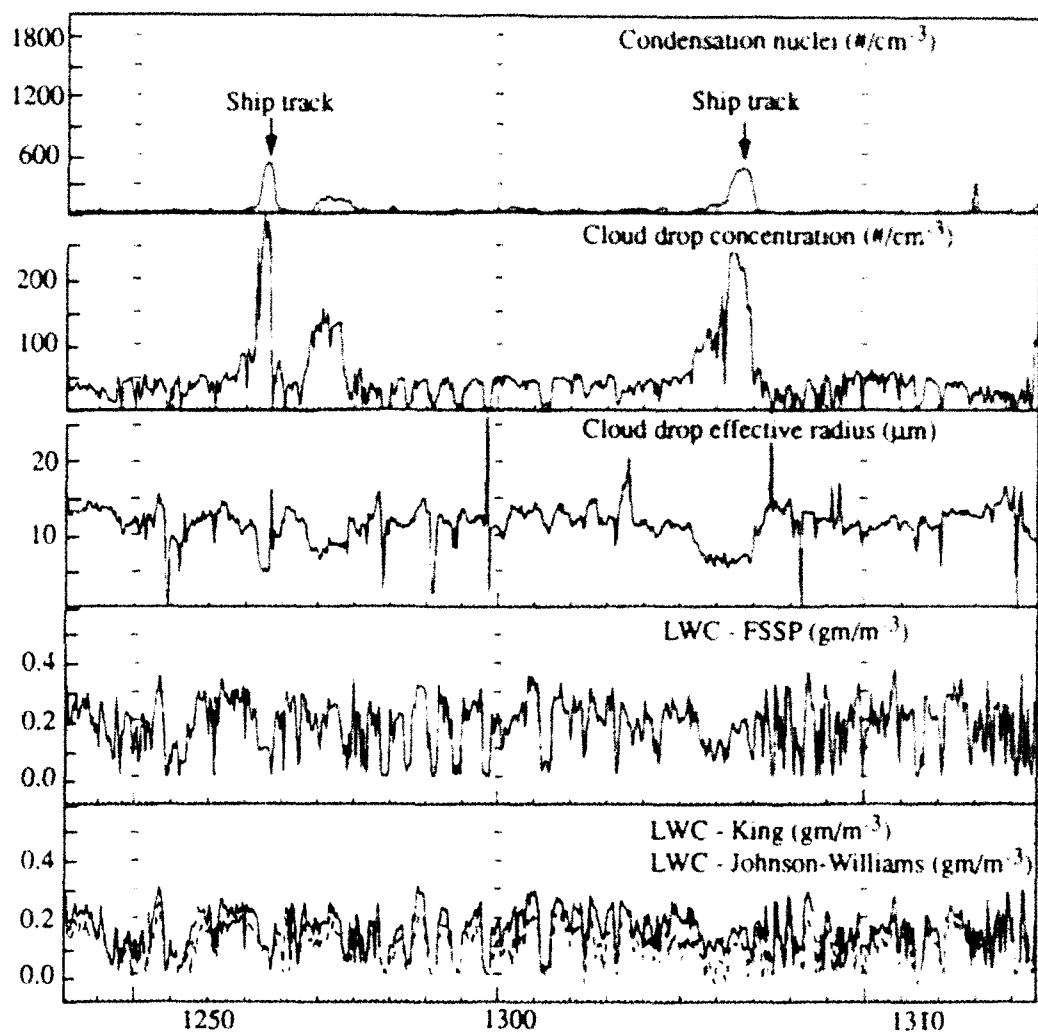


Figure 2



DEPARTMENT OF THE NAVY
OFFICE OF NAVAL RESEARCH
800 NORTH QUINCY STREET
ARLINGTON, VA 22217 5660

IN REPLY REFER TO

1241/001
04 JAN 93

Dear Colleague:

Welcome to the new year. Because you were a grantee from the ONR Atmosphere and Ocean Variability Program (ONR Code 1241), I need a summary report of your activities during 1992. This report can be submitted electronically via OMNET (G.GEERNAERT/OMNET), or by regular mail. This report is due to ONR by February 5, 1993. Any questions regarding the report submittal can be obtained by contacting me by OMNET or telephone (703 696 2496).

The report should be structured by providing the following information related to those research efforts which were based all or in part on ONR funding.

1. Total papers submitted and/or published in refereed journals by Dec 31, 1992: 1
Please also submit copies of papers or abstracts.

2. Total papers scheduled to be published at a later date in refereed journals: more than one
Identify also the tentative titles and, if possible, abstracts.

3. Total papers published or accepted in non-refereed journals: 1
Please provide titles and abstracts.

4. Number of Technical Reports: 0. List the titles and abstracts.

5. Number of Books published: 0. List the titles and abstracts.

6. Number of book chapters published, other than in #5: 1. List the titles and abstracts.

7. Number of patent applications: 0

Patent application numbers: _____

Patent numbers: _____

8. Number of significant presentations: 1 by R. J. Ferek, 1 invited talk by M. D. King

Forum, date and title of the most significant. For each of 1 to 3 most significant presentations, please include no more than a few sentences describing its significance.

9. Honors and awards received by principal investigators: please include title, recipient, and date. Underline those that might have been the result of ONR funding.

10. Total number of different post-docs supported at least 25% of the time: 0

11. Number of different graduate students supported at least 25% of the time? 0

12. List the most significant publications in citation format (authors, year, title, publication name, volume, number, page) and up to ten lines why the publication is truly significant.

13. Major Accomplishments, organized by objective, of your funded research in (five to six succinct lines of text in a paragraph, include specific references, where possible).

14. Significant transitions; if any follow-on research has begun or been proposed, identify the sponsor, funding level, and contact person (phone number) who can provide additional information.

Sponsor:

Funding level: (\$ in FY XX)

Sponsor Phone number for additional information:

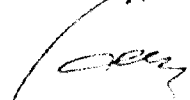
15. Impact of your research; new research areas identified and/or stimulated and accomplishments other than listed above.

16. Key words describing research: ship tracks, cloud albedo, effective radius of cloud drops

17. Key words describing technologies impacted by your research:

I will look forward to your reports.

Sincerely,



G. L. Geernaert

ONR Code 1241

800 N. Quincy Street

Arlington, VA 22217